इंटरनेट मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

"जानने का अधिकार, जीने का अधिकार"
Mazdoor Kisan Shakti Sangathan
"The Right to Information, The Right to Live"

"पुराने को छोड नये के तरफ"
Jawaharlal Nehru
"Step Out From the Old to the New"

IS 14659 (1999): A. C. Insulation-Enclosed Switchgear and Controlgear for Rated Voltages Above 1 kV and up to and Including 38 Kv [ETD 8: High Voltage Switchgear and Controlgear]

"ज्ञान से एक नये भारत का निर्माण"
Satyanarayan Gangaram Pitroda
"Invent a New India Using Knowledge"

Act Number 22 of 2005
The Indian Parliament
RIGHT TO INFORMATION

Made Available By
Public.Resource.Org

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

BLANK PAGE

BRUTUM FULMEN

IGNORANTIA JURIS NON EXCUSAT

PROTECTED BY COPYRIGHT

IS 14659 : 1999
IEC 466 (1987)

(Reaffirmed 2004)

भारतीय मानक

1 के. वी. से 38 के. वी. तक की रेटित वोल्टता के लिए परिबद्ध विद्युतरोधन वाले ए सी स्विचगियर और कंट्रोलगियर

Indian Standard

A. C. INSULATION-ENCLOSED SWITCHGEAR AND CONTROLGEAR FOR RATED VOLTAGES ABOVE 1 kV AND UP TO AND INCLUDING 38 kV

ICS 29.120.60

© BIS 1999

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

February 1999

Price Group 14

High Voltage Switchgear and Controlgear Sectional Committee, ET 08

NATIONAL FOREWORD

This Indian Standard which is identical with IEC 466 (1987) 'A. C. insulation-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 38 kV', issued by the International Electrotechnical Commission (IEC), was adopted by the Bureau of Indian Standards on the recommendations of the High Voltage Switchgear and Controlgear Sectional Committee (ET 08) and approval of the Electrotechnical Division Council. It gives requirements for factory assembled insulation-enclosed switchgear and controlgear for alternating current of rated voltages above 1 kV and up to and including 38 kV for indoor installation and for service frequencies up to and including 60 Hz.

The text of the IEC 466 (1987) along with its Amendment No. 1 has been approved as suitable for publication as Indian Standard without deviations.

In the adopted standard, certain terminology and conventions are not identical to those used in Indian Standards. Attention is specially drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their place are listed below along with their degree of equivalence for editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 50 (151) : 1978 International Electrotechnical Vocabulary — Chapter 151 : Electric and magnetic devices	IS 1885 (Part 42) : 1993	Identical
IEC 50 (441) : 1984 Chapter 441 : Switchgear, controlgear and fuses	IS 1885 (Part 17) : 1979	Technically Equivalent
IEC 56 : 1987 High-voltage alternating current circuit breakers	IS 13118 : 1991	Identical
IEC 60-1 : 1973 High-voltage test techniques, Part 1 : General definitions and test requirements	IS 2071 (Part 1) : 1993	do
IEC 129 : 1984 Alternating current disconnectors and earthing switches	IS 9921 (Parts 1 to 4)	Partially Equivalent
IEC 243 : 1967 Recommended methods of test for electric strength of solid insulating materials at power frequencies	IS 2584 : 1963	Equivalent
IEC 270 : 1981 Partial discharge measurements	IS 6209 : 1982	do

(*Continued on third cover*)

CONTENTS

Page

Clause

1. Scope ... 3
2. Normal and special service conditions ... 3
3. Definitions ... 3
4. Rating ... 6
  4.1 Rated voltage ... 7
  4.2 Rated insulation level ... 7
  4.3 Rated frequency ... 7
  4.4 Rated normal current and temperature rise ... 7
  4.5 Rated short-time withstand current ... 7
  4.6 Rated peak withstand current ... 8
  4.7 Rated duration of short-circuit ... 8
  4.8 Rated supply voltage of closing and opening devices and auxiliary circuits ... 8
  4.9 Rated supply frequency of operating devices and auxiliary circuits ... 8
  4.10 Rated pressure of compressed gas supply for operation ... 8
5. Design and construction ... 8
  5.1 Requirements for liquids in switchgear and controlgear ... 8
  5.2 Requirements for gases in switchgear and controlgear ... 9
  5.3 Earthing ... 9
  5.4 Auxiliary equipment ... 9
  5.5 Dependent power closing ... 9
  5.6 Stored energy closing ... 9
  5.7 Operation of releases ... 9
  5.8 Low and high pressure interlocking devices ... 9
  5.9 Nameplates ... 10
  5.101 Degree of protection ... 10
  5.102 Internal fault ... 11
  5.103 Insulation enclosure ... 11
  5.104 Shutters ... 13
  5.105 Disconnectors and earthing switches ... 14
  5.106 Interlocks ... 14
  5.107 Provisions for dielectric tests on cables ... 15
6. Type tests ... 15
  6.1 Dielectric tests ... 16
  6.2 Radio interference voltage (RIV) tests ... 23
  6.3 Temperature-rise tests ... 23
  6.4 Measurement of the resistance of the main circuit ... 23
  6.5 Short-time and peak withstand current tests ... 23
  6.101 Verification of making and breaking capacities ... 24
  6.102 Mechanical operation tests ... 24
  6.103 Verification of the degree of protection ... 25

Clause Page

6.104 Measurement of leakage currents 25
6.105 Mechanical strength test 26
6.106 Test under conditions of arcing due to internal fault 27
6.107 Thermal stability test 27
6.108 Humidity test 27
6.109 Ageing tests 27

7. Routine tests 27
7.1 Power-frequency voltage tests on the main circuit 28
7.2 Dielectric tests on auxiliary and control circuits 28
7.3 Measurement of the resistance of the main circuit 28
7.101 Mechanical operation tests 28
7.102 Tests of auxiliary electrical, pneumatic and hydraulic devices 29
7.103 Verification of the correct wiring 29
7.104 Partial discharge measurement 29

8. Guide to the selection of switchgear and controlgear for service 29

9. Information to be given with enquiries, tenders and orders 30
9.101 Information to be given with enquiries and orders 30
9.102 Information to be given with tenders 31

10. Rules for transport, storage, erection and maintenance 31
10.1 Conditions during transport, storage and erection 31
10.2 Erection 31
10.3 Maintenance 31

Appendix AA – Internal fault 34
Method for testing the enclosed switchgear and controlgear under conditions of arcing due to internal fault 35

Appendix BB – Humidity test 42

Appendix CC – Rated insulation level for Series II 46

Appendix DD – Guide for dielectric tests after erection on site 46

Indian Standard

A. C. INSULATION-ENCLOSED SWITCHGEAR AND CONTROLGEAR FOR RATED VOLTAGES ABOVE 1 kV AND UP TO AND INCLUDING 38 kV

1. Scope

This standard specifies requirements for factory-assembled insulation-enclosed switchgear and controlgear for alternating current of rated voltages above 1 kV and up to and including 38 kV for indoor installation, and for service frequencies up to and including 60 Hz.

Note. – In some countries the highest voltage for equipment is 40.5 kV.

Insulation-enclosed switchgear and controlgear for special use, for example in flammable atmospheres, in mines or in ships, may be subject to additional requirements.

This standard does not deal with components contained in insulation-enclosed switchgear and controlgear for which individual specifications exist.

Notes 1. – Switchgear and controlgear assemblies having a metal enclosure are covered by IEC Publication 298: A.C. Metal-enclosed Switchgear and Controlgear for Rated Voltages above 1 kV and up to and including 72.5 kV.

2. – While this standard also covers insulation-enclosed switchgear and controlgear the insulation of which is an insulating fluid other than air at atmospheric pressure, additional requirements for such equipment may apply depending on its design.

For the purpose of this standard, when the term "switchgear" is used alone, it corresponds to "insulation-enclosed switchgear and controlgear".

2. Normal and special service conditions

Unless otherwise specified, the insulation-enclosed switchgear and controlgear is designed to be used under normal indoor service conditions.

Refer to Sub-clause 2.1.1 of IEC Publication 694: Common Clauses for High-voltage Switchgear and Controlgear Standards. In all other cases the manufacturer should be consulted.

3. Definitions

For the definitions of general terms used in this standard, reference is made to IEC Publication 50(441): International Electrotechnical Vocabulary (IEV), Chapter 441: Switchgear, Controlgear and Fuses, and IEC Publication 50(151): Chapter 151: Electrical and Magnetic Devices. The following definitions apply for the purpose of this standard.

3.101 *Switchgear and controlgear*

A general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures (IEV 441-11-01).

3.102 *Insulation-enclosed switchgear and controlgear*

Switchgear and controlgear assemblies with an external insulation enclosure and complete except for external connections (IEV 441-12-06).

3.103 *Transport unit*

A part of insulation-enclosed switchgear and controlgear suitable for shipment without being dismantled.

3.104 *Functional unit*

A part of insulation-enclosed switchgear and controlgear comprising all the components of the main circuits and auxiliary circuits that contribute to the fulfilment of a single function (IEV 441-13-04).

Note. – Functional units may be distinguished according to the function for which they are intended, for example: incoming unit, outgoing unit, etc.

3.105 *Insulation enclosure*

A part of solid insulation surrounding the insulation-enclosed switchgear and controlgear used as protection against dangerous electrical effects, and intended to protect persons against approach to or contact with live parts and against contact with moving parts contained therein and to protect the equipment against external influences.

3.106 *Insulation-embedded component*

A component, the live parts of which are, with the exception of the terminals, integrally surrounded by solid insulation.

Note. – The insulation may form part of the insulation enclosure.

3.107 *Component*

An essential part of the main or earthing circuits of insulation-enclosed switchgear and controlgear which serves a specific function (for example circuit-breaker, disconnector, switch, fuse, instrument transformer, bushing, busbar, etc.).

3.108 *Shutter*

A part of insulation-enclosed switchgear and controlgear that can be moved from a position where it permits contacts of a removable part to engage fixed contacts, to a position where it becomes a part of the insulation enclosure shielding the fixed contacts (IEV 441-13-07).

3.109 *Removable part*

A part of insulation-enclosed switchgear and controlgear that may be removed entirely from the insulation-enclosed switchgear and controlgear and replaced, even though the main circuit is alive (IEV 441-13-08).

3.110 *Withdrawable part*

A removable part of insulation-enclosed switchgear and controlgear that can be moved to one or more positions in which an isolating distance or a segregation between open contacts is established, while the part remains mechanically attached to the switchgear (IEV 441-13-09).

3.111 *Segregation* (between conductors)

An arrangement of conductors with earthed metal interposed between them in such a manner that disruptive discharges can only occur to earth (IEV 441-11-11).

Note. – A segregation may be established between the conductors as well as between the open contacts of a switching device.

3.112 *Service position/connected position* (of a removable part)

The position of a removable part in which it is fully connected for its intended function (IEV 441-16-25).

3.113 *Earthing position* (of a removable part)

The position of a removable part in which the closing of a mechanical switching device causes a main circuit to be short-circuited and earthed (IEV 441-16-26).

3.114 *Test position* (of a withdrawable part)

The position of a withdrawable part in which an isolating distance or segregation is established in the main circuit and in which the auxiliary circuits are connected (IEV 441-16-27).

3.115 *Disconnected position* (of a withdrawable part)

The position of a withdrawable part in which an isolating distance or a segregation is established in the circuits of the withdrawable part, that part remaining mechanically attached to the switchgear (IEV 441-16-28).

Note. – In enclosed high-voltage switchgear and controlgear, the auxiliary circuits may remain connected.

3.116 *Removed position* (of a removable part)

A position of a removable part when it is outside and mechanically and electrically separated from the switchgear (IEV 441-16-29).

3.117 *Main circuit*

All the conductive parts of insulation-enclosed switchgear and controlgear included in a circuit which is intended to transmit electrical energy (IEV 441-13-02).

Note. – Connections to voltage transformers are not considered part of the main circuit.

3.118 *Auxiliary circuit*

All the conductive parts of insulation-enclosed switchgear and controlgear included in a circuit (other than the main circuit) intended to control, measure, signal and regulate (IEV 441-13-03).

Note. – The auxiliary circuits of insulation-enclosed switchgear and controlgear include the control and auxiliary circuits of the switching devices.

3.119 *Rated value*

A quantity value assigned, generally by a manufacturer, for a specified operating condition of insulation-enclosed switchgear and controlgear (IEV 151-04-03).

Note. – See Clause 4 for individual rated values.

3.120 *Degree of protection*

The degree of protection provided by an insulation enclosure to protect persons against contact with or approach to live parts and against contact with moving parts inside the insulation enclosure and to protect the equipment against ingress of solid bodies.

3.121 *Ambient air temperature* (of insulation-enclosed switchgear and controlgear)

The temperature determined under prescribed conditions of the air surrounding the external enclosure of insulation-enclosed switchgear and controlgear.

3.122 *Disruptive discharge*

Phenomena associated with the failure of insulation under electric stress, in which the discharge completely bridges the insulation under test, reducing the voltage between the electrodes to zero or nearly to zero.

Notes 1. – The term applies to discharges in solid, liquid and gaseous dielectrics and to combinations of these.

2. – A disruptive discharge in a solid dielectric produces permanent loss of dielectric strength (non-self-restoring insulation); in a liquid or gaseous dielectric, the loss may be only temporary (self-restoring insulation).

3. – The term "sparkover" is used when a disruptive discharge occurs in a gaseous or liquid dielectric;

– the term "flashover" is used when a disruptive discharge occurs over the surface of a solid dielectric in a gaseous or liquid medium;

– the term "puncture" is used when a disruptive discharge occurs through a solid dielectric.

4. Rating

The rating of insulation-enclosed switchgear and controlgear comprises the following:

a) rated voltage and number of phases;

b) rated insulation level;

c) rated frequency;

d) rated normal current (for main circuits);

e) rated short-time withstand current (for main and earthing circuits);

f) rated peak withstand current, if applicable (for main and earthing circuits);

g) rated duration of short circuit;

h) rated values of the components forming part of the insulation-enclosed switchgear and controlgear including their operating devices and auxiliary equipment.

For the co-ordination of rated voltages, rated short-time withstand currents, rated peak withstand currents and rated normal currents of insulation-enclosed switchgear and controlgear reference is made to Clause 4 of IEC Publication 56: High-voltage Alternating-current Circuit-breakers, and to IEC Publication 129: Alternating-current Disconnectors and Earthing Switches.

4.1 *Rated voltage*

Refer to Sub-clauses 4.1 and 4.1.1 of IEC Publication 694 but only the following standard values of rated voltages are to be applied:

Series I 3.6 kV – 7.2 kV – 12 kV – 17.5 kV – 24 kV – 36 kV
Series II 4.76 kV – 8.25 kV – 15 kV – 15.5 kV – 25.8 kV – 38 kV

Note. – Components forming part of the switchgear may have individual values of rated voltage in accordance with the relevant standards.

4.2 *Rated insulation level*

Refer to Sub-clauses 4.2 and 4.2.1 of IEC Publication 694 restricted to rated voltages up to and including 38 kV. The rated withstand voltage values, based on current practice in Canada and the United States of America, are given in the table of Appendix CC.

4.3 *Rated frequency*

Refer to Sub-clause 4.3 of IEC Publication 694, with the addition of the following rated values:

16⅔ Hz and 25 Hz.

4.4 *Rated normal current and temperature rise*

4.4.1 *Rated normal current*

Refer to Sub-clause 4.4.1 of IEC Publication 694 with the addition of the following paragraph:

Some main circuits of insulation-enclosed switchgear and controlgear (e.g. busbars, feeder circuits, etc.) may not have the same value of rated normal current.

4.4.2 *Temperature rise*

Refer to Sub-clause 4.4.2 of IEC Publication 694 with the addition of the following supplement:

The temperature rise of components contained in the switchgear which are subject to standards not covered by the scope of IEC Publication 694 shall not exceed the temperature-rise limits permitted in the relevant standard for those components.

The temperature rise of accessible enclosures and covers shall not exceed 30 K for metal surfaces and 40 K for insulation surfaces. In the case of enclosures and covers which are accessible but need not be touched during normal operation, the temperature-rise limits may be increased by 10 K.

4.5 *Rated short-time withstand current*

Refer to Sub-clause 4.5 of IEC Publication 694.

4.6 *Rated peak withstand current*

Refer to Sub-clause 4.6 of IEC Publication 694.

Note. – In principle the rated short-time withstand current and the rated peak withstand current of a main circuit cannot exceed the corresponding rated values of the weakest of its series connected components. However, for each circuit or compartment, advantage may be taken of apparatus limiting the short-circuit current, such as current-limiting fuses, reactors, etc.

4.7 *Rated duration of short circuit*

Refer to Sub-clause 4.7 of IEC Publication 694.

4.8 *Rated supply voltage of closing and opening devices and auxiliary circuits*

Refer to Sub-clause 4.8 of IEC Publication 694.

4.9 *Rated supply frequency of operating devices and auxiliary circuits*

Refer to Sub-clause 4.9 of IEC Publication 694.

4.10 *Rated pressure of compressed gas supply for operation*

Refer to Sub-clause 4.10 of IEC Publication 694.

5. Design and construction

Insulation-enclosed switchgear and controlgear shall be designed so that normal service, inspection and maintenance operations, including the usual checking of phase sequence, earthing of connected cables, locating of cable faults, voltage tests on connected cables or other apparatus and the elimination of dangerous electrostatic charges, can be carried out safely.

For insulation-enclosed switchgear and controlgear it is necessary to take into account condensation and humidity conditions because such equipment has to be safe for persons touching it, not only in a dry state but also with condensation on insulation surfaces.

All components of the same rating and construction which may need to be replaced shall be interchangeable.

If there are removable parts with different rating and if parts are interchangeable within the assembly of insulation-enclosed switchgear and controlgear, any possible combination of removable and fixed parts shall withstand at least the rated insulation level specified for the fixed parts of the equipment concerned.

The various components within the insulation enclosure are subject to the individual specifications applying to them.

For main circuits with current-limiting fuses, the manufacturer of the switchgear may assign the fused short-circuit current.

5.1 *Requirements for liquids in switchgear and controlgear*

Refer to Sub-clause 5.1 of IEC Publication 694.

5.2 *Requirements for gases in switchgear and controlgear*

Refer to Sub-clause 5.2 of IEC Publication 694.

5.3 *Earthing*

Refer to Sub-clause 5.3 of IEC Publication 694 with the addition of the following supplement:

An earthing conductor shall be provided extending the whole length of the insulation-enclosed switchgear and controlgear. The current density in the earthing conductor, if of copper, shall not exceed 200 A/mm^2 under the specified earth fault conditions; however, cross-sectional area of the conductor shall be not less than 30 mm^2. It shall be terminated by an adequate terminal intended for connection to the earth system of the installation.

Note. – If the earthing conductor is not made of copper, equivalent thermal and mechanical requirements should be met.

All accessible metal parts which do not belong to a main or auxiliary circuit, and which can collect electric charges causing dangerous effects, shall be connected to the earthing conductor.

In general, the continuity of the earth system shall be ensured taking into account the thermal and mechanical stresses caused by the current it may have to carry. The maximum value of earth fault currents depends upon the type of system neutral earthing employed and shall be indicated by the user.

Where earthing connections have to carry the full three-phase short-circuit current (as in the case of the short-circuiting connections used for earthing devices) these connections shall be dimensioned accordingly.

Each part of the main circuit which can be disconnected from the other parts shall be capable of being short-circuited and earthed.

The metallic parts of a withdrawable part which are normally earthed shall also remain earthed in the test or disconnected position and also in any intermediate position whilst the auxiliary circuits are not totally disconnected (for conditions concerning the isolating distance see IEC Publication 129).

5.4 *Auxiliary equipment*

Refer to Sub-clause 5.4 of IEC Publication 694.

5.5 *Dependent power closing*

Refer to Sub-clause 5.5 of IEC Publication 694.

5.6 *Stored energy closing*

Refer to Sub-clause 5.6 of IEC Publication 694.

5.7 *Operation of releases*

Refer to Sub-clause 5.7 of IEC Publication 694.

5.8 *Low and high pressure interlocking devices*

Refer to Sub-clause 5.8 of IEC Publication 694.

5.9 *Nameplates*

Refer to Sub-clause 5.9 of IEC Publication 694, with the addition of the following supplement:

Insulation-enclosed switchgear and controlgear and all components and operating devices shall be provided with durable and clearly legible nameplates which shall contain the following information:

- manufacturer's name or trade mark;
- type designation or serial number;
- applicable rated values;
- number of the relevant standard.

The nameplates of each functional unit shall be legible during normal service. The removable parts, if any, shall have a separate nameplate with the data relating to the functional units they belong to, but this nameplate need be legible only when the removable part is removed.

Note. – The word "rated" need not appear on the nameplate.

5.101 *Degree of protection*

5.101.1 *Protection of persons against approach to live parts and contact with moving parts*

The degree of protection provided by the insulation enclosure shall be indicated by means of a designation specified in Table I.

The characteristic numeral indicates the degree of protection provided by the enclosure with respect to persons, also to the equipment inside the enclosure.

Table I gives details of objects which will be "excluded" from the enclosure for each of the degrees of protection.

The term "excluded" implies that a part of the body or of an object greater than the specified value held by a person either will not enter the enclosure or, if it enters, that adequate clearance will be maintained and no moving part will be touched.

TABLE I

Degree of protection	Protection against approach to live parts and contact with moving parts
IP2X	By fingers or similar objects of diameter greater than 12 mm
IP3X	By tools, wires etc., of diameter or thickness greater than 2.5 mm
IP4X	By wires of diameter or strips of thickness greater than 1.0 mm

Note. – The designation of the degree of protection corresponds to IEC Publication 529: Classification of Degrees of Protection Provided by Enclosures. No degree of protection against the harmful ingress of water is specified.

5.101.2 *Protection of equipment against external effects*

a) Protection against ingress of solid bodies:
No additional provision beyond those indicated in Sub-clause 5.101.1 are to be taken.

b) Protection against atmospheric agents:
As to the relevant service conditions to be observed see Clause 2.

5.101.3 *Protection of equipment against mechanical damage*

All insulation enclosures shall be of sufficient mechanical strength (for tests, see Sub-clause 6.105).

5.102 *Internal fault*

Failure within the enclosure of insulation-enclosed switchgear and controlgear due either to defects or exceptional service conditions or a mal-operation may initiate an internal arc.

There is little probability of such a failure occurring in constructions which satisfy the requirements of this standard, but it cannot be completely disregarded.

Such a failure may lead to injury, if persons are present, but with an even lower probability.

It is desirable that the highest possible degree of protection to persons should be provided. The principal objective should be to avoid such arcs or to limit their duration and consequences.

Experience has shown that faults are more likely to occur in some locations inside an enclosure than in others, so special attention should be paid to these.

For guidance, a list of such locations and of causes is given in Table AAI of Appendix AA, columns (1) and (2). Measures to decrease the probability of internal faults or to reduce the risk are recommended in column (3). Examples of measures to limit the consequences of internal faults are given in Table AAII of Appendix AA.

If such measures are considered to be insufficient, and to cover only the case of an arc occurring entirely in air within the enclosure of the insulation-enclosed switchgear and controlgear, a test in accordance with Appendix AA may be agreed between the manufacturer and user, to verify that the chosen criteria are fulfilled as agreed.

Such a test should be unnecessary on those parts of circuits which are protected by current-limiting devices, for example, fuses.

Note. – The overpressure in the building caused by arcing due to an internal fault in the enclosure and the effects of the ejection of gases from pressure relief devices should be taken into consideration.

5.103 *Insulation enclosure*

5.103.1 *General*

The complete insulation enclosure as well as the materials used in the construction shall be capable of withstanding the mechanical, electrical and thermal stresses as well as the effects of humidity and ageing which are likely to be encountered in normal service conditions.

The main parts of the insulation enclosure may be considered as consisting of non-self-restoring insulation.

The walls and the floor of a room shall not be considered as parts of the enclosure.

5.103.2 *Protection of persons against dangerous electrical effects*

The insulation enclosure shall provide protection of persons against dangerous electrical effects when touching the enclosure or operating insulation-enclosed switchgear and controlgear. The following two grades of protection are distinguished:

Protection grade A with an insulation which meets all the requirements given in the Items *a)* to *c)* of Sub-clause 5.103.3 is generally sufficient for those parts of the enclosure which are touched by persons only accidentally or inadvertently.

Protection grade B with an insulation which meets, in addition to those of protection grade A, the requirements given in Item *d)* or *e)* of Sub-clause 5.103.3 as a safeguard in case the protection grade A insulation is damaged. Protection grade B is considered as suitable for parts which are liable to be touched when operating, when replacing removable parts or when carrying out other normal maintenance work.

Note. – Protection equivalent to protection grade B may be obtained by an earthed metal cover. For such equipment, the requirements of IEC Publication 298 apply.

This standard provides for insulation-enclosed switchgear and controlgear which has either:

- protection grade B throughout for generally accessible installations (operating areas), or
- partly protection grade A and partly protection grade B for installations accessible to skilled operators only (closed electrical operating areas).

Note. – For the definitions of "operating area" and "closed electrical operating area" refer to IEC Publication 621-1: Electrical Installations for Outdoor Sites under Heavy Conditions (Including Open-cast Mines and Quarries), Part 1: Scope and Definitions.

5.103.3 *Conditions for insulation enclosures*

For protection grade A, the insulation enclosure shall meet the following requirements:

a) The insulation between parts of the main circuit and the accessible surface of the insulation enclosure of the total assembly shall be capable of withstanding the test voltages specified in Sub-clause 6.1.5 for dielectric tests to earth and between phases.

b) Apart from mechanical considerations, the thickness of the insulating material of insulation enclosures shall be sufficient to withstand the test voltages specified in Item *a)*. The methods specified in IEC Publication 243: Recommended Methods of Test for Electric Strength of Solid Insulation Materials at Power Frequencies, should be applied to the tests to meet the relevant requirements.

c) Capacitive and leakage currents shall not be greater than 0.5 mA under the specified test conditions.

For protection grade B, the requirements of protection grade A and one of the following additional requirements shall be met by the insulation enclosure:

d) The insulation enclosure shall consist of at least two layers of insulating material, one of which shall comply with the requirements of Item *b).* The other layer need be able to withstand only a 1 min power-frequency test voltage equal to 150% of the rated voltage. It shall not be possible to remove the additional insulation without the aid of a tool.

e) The insulation enclosure contains a gaseous or liquid insulant. In this case, it shall be ensured that, when the gaseous or liquid insulant is replaced by ambient air at normal atmospheric pressure, the insulation of the main circuit with respect to the internal surface of the insulation enclosure is capable of withstanding a 1 min power-frequency test voltage equal to 150% of the rated voltage.

5.103.4 *Covers and doors*

Covers and doors shall, when they are closed, provide the degree of protection specified for the insulation enclosure.

Two categories of covers and doors are recognized with regard to access to high-voltage compartments:

a) those which need not be opened for the normal purposes of operation or maintenance (fixed covers). It shall not be possible for them to be opened, dismantled or removed without the use of tools;

b) those which need to be opened for the normal purposes of operation (removable covers, doors). These shall not require tools for their opening or removal. They shall be provided with locking facilities (for example, provision for padlocks), unless the safety of persons is assured by a suitable interlocking device.

5.103.5 *Inspection windows*

Inspection windows shall be covered by transparent sheets of mechanical strength comparable to that of the insulation enclosure. They shall meet at least the requirements of insulation enclosures specified for protection grade B.

5.103.6 *Ventilating openings, vent outlets*

Ventilating openings and vent outlets shall be so arranged or shielded that the same degree of protection as that specified for the insulation enclosure is obtained. Such openings may make use of wire mesh or the like provided that it is of suitable mechanical strength.

Ventilating openings and vent outlets shall be arranged in such a way that gas or vapour escaping under pressure does not endanger the operator.

5.104 *Shutters*

Openings in the enclosure through which contacts of removable parts engage fixed contacts, shall be provided with automatic shutters or other devices to ensure the degree of protection specified for the enclosure in any of the positions to be taken by the removable parts. The shutters shall also meet the requirements specified for protection grade B.

If maintenance requirements imply that one set of fixed contacts shall be accessible through opened shutters, all the shutters shall be provided with means of locking them independently in the closed position.

5.105 *Disconnectors and earthing switches*

The devices for ensuring the isolating distance between high-voltage conductors are considered to be disconnectors and shall comply with IEC Publication 129, except for mechanical operation tests for which Sub-clauses 6.102 and 7.101 apply.

Leakage currents across the isolating distance shall not exceed 0.5 mA. The measurement of leakage currents shall be carried out in accordance with the method specified in Sub-clause 6.104.

The requirement of IEC Publication 129, that it shall be possible to know the operating position of the disconnector or earthing switch is met, if one of the following conditions is fulfilled:

- the isolating distance is visible;
- the position of the withdrawable part, in relation to the fixed part, is clearly visible and the positions corresponding to full connection and full isolation are clearly identified;
- the position of the disconnector or earthing switch is indicated by a reliable indicating device.

Any removable part shall be so attached to the fixed part that its contacts will not open inadvertently due to forces which may occur in service, in particular those due to a short circuit.

5.106 *Interlocks*

Interlocks between different components of the equipment are provided for reasons of safety and for convenience of operation. The following provisions are mandatory for main circuits:

a) Insulation-enclosed switchgear and controlgear with removable parts

The withdrawal or engagement of a circuit-breaker, switch or contactor shall be impossible unless it is in the open position.

The operation of a circuit-breaker, switch or contactor shall be impossible unless it is in the service, disconnected, removed, test or earthing position.

It shall be impossible to close the circuit-breaker, switch or contactor in the service position unless it is connected to the auxiliary circuit, unless it is designed to open automatically without the use of an auxiliary circuit.

b) Insulation-enclosed switchgear and controlgear without removable parts but provided with disconnectors

Interlocks shall be provided to prevent operation of disconnectors under conditions other than those they are intended for (see IEC Publication 129). The operation of a disconnector shall be impossible unless the associated circuit-breaker, switch or contactor is in the open position.

Note: – This rule may be disregarded if it is possible to have a busbar transfer in a double busbar system without current interruption.

The operation of the circuit-breaker, switch or contactor shall be impossible unless the associated disconnector is in the closed, open or earthing position (if provided).

The provision of additional or alternative interlocks shall be subject to agreement between manufacturer and user. The manufacturer shall give all necessary information on the character and function of interlocks.

It is recommended that earthing switches having a short-circuit making capacity less than the rated peak withstand current of the circuit should be interlocked with the associated disconnectors.

Apparatus installed in main circuits, the incorrect operation of which can cause damage or which is used for ensuring isolating distances during maintenance work, shall be provided with locking facilities (for example, provision for padlocks).

Note. – Whenever practical, preference should be given to mechanical interlocks.

5.107 *Provisions for dielectric tests on cables*

When, for the dielectric tests, it is not practical to disconnect the cable from the insulation-enclosed switchgear and controlgear, those parts which remain connected to the cable shall be capable of withstanding the cable test voltages specified in the relevant cable standards for the same rated voltage.

Note. – Attention is drawn to the fact that practically no safety margin is left in some cases between the rated power-frequency test voltage for the isolating distance and the resulting voltage stress across the isolating distance due to the application of the d.c. cable test voltage, while the other side of the isolating distance of the switchgear is still live.

6. Type tests

Refer to Clause 6 of IEC Publication 694, with the addition of the following modification:

Components contained in insulation-enclosed switchgear and controlgear which are subject to individual specifications not covered by the scope of IEC Publication 694 shall comply with and be tested in accordance with those specifications, taking into account the conditions given in the following sub-clauses.

The type tests are made on a representative functional unit. Because of the variety of types, rating and possible combinations of components, it is impracticable to subject all arrangements of the switchgear to type tests. The performance of any particular arrangement may be substantiated by test data of comparable arrangements.

Note. – A representative functional unit may take the form of one extensible unit. However, it may be necessary to bolt two or three such units together.

The type tests and verifications comprise:

	Sub-clause
1) *Normal type tests*	
a) Tests to verify the insulation level of the equipment including tests at power-frequency test voltages on auxiliary circuits:	6.1

	Sub-clause
b) Tests to prove the temperature rise of any part of the equipment and measurement of the resistance of the main circuit:	6.3 and 6.4
c) Tests to prove the capability of the main and earthing circuits to be subjected to the rated peak and the rated short-time withstand currents:	6.5
d) Tests to prove the making and breaking capacity of the included switching devices:	6.101
e) Tests to prove the satisfactory operation of the included switching devices and removable parts:	6.102
f) Tests to verify the protection of persons against approach to live parts and contact with moving parts:	6.103
g) Tests to verify the protection of persons against dangerous electrical effects:	6.104
2) *Special type tests (subject to agreement between manufacturer and user)*	
h) Tests to prove the mechanical strength of the insulation enclosure:	6.105
i) Tests to assess the effects of arcing due to an internal fault:	6.106
j) Tests to detect certain defects in the solid insulation of the equipment by the measurement of partial discharges:	6.1.9
k) Tests to verify the thermal stability of insulating materials:	6.107
l) Tests to assess the effects of condensation on insulation surfaces:	6.108

Note. – Some of the type tests may impair the suitability of the tested parts for subsequent use in service.

6.1 *Dielectric tests*

6.1.1 *Ambient air conditions during tests*

Refer to Sub-clause 6.1.1 of IEC Publication 694, with the following supplement:

Where the insulation of insulation-enclosed switchgear and controlgear comprises atmospheric air, voltage tests and the measurement of partial discharges shall be made in conditions as near as possible to the standard reference atmosphere (see IEC Publication 60-1: High-voltage Test Techniques, Part I: General Definitions and Test Requirements).

6.1.2 *Wet test procedure*

IEC Publication 694 is not applicable as insulation-enclosed switchgear and controlgear is suitable only for indoor use.

6.1.3 *Conditions of switchgear and controlgear during dielectric tests*

Refer to Sub-clause 6.1.3 of IEC Publication 694 for those tests which are applicable.

6.1.4 *Application of test voltages and test conditions*

IEC Publication 694 is not applicable. Because of the great variety of designs, it is not feasible to give specific indications of the tests to be performed on the main circuit. In principle, they shall cover the following tests:

a) To earth and between phases

The test voltages specified in Sub-clause 6.1.5 shall be applied by connecting each phase conductor of the main circuit in turn to the high-voltage terminal of the test supply. All other conductors of the main circuit and the auxiliary circuits are to be connected to the earthing conductor and to the earth terminal of the test supply.

Areas of the insulation enclosure intended for resting on the floor or being fixed to the wall shall be covered by earthed metal foils.

In order to check compliance with the requirement of Item *a)* of Sub-clause 5.103.3 the insulation enclosure shall be covered, on the side accessible during operation or maintenance, in the most unfavourable situation for the test, with a circular or square metal foil having an area as large as possible, but not exceeding 100 cm^2 which shall be connected to earth. In case of doubt about the most unfavourable situation, the test shall be repeated in different situations. This foil shall be applied on the external surface of the enclosure without protruding into small gaps. For convenience of testing, subject to agreement between manufacturer and user, more than one metal foil may be applied simultaneously or larger parts of the enclosure may be covered.

Note. – If a sub-assembly is tested, it should include joints of insulation-embedded components if these are used.

The dielectric tests shall be made with all switching devices closed and all removable parts in their service position. Attention shall be given to the possibility that switching devices in their open position or removable parts in the disconnected, removed, test or earthing position, may result in less favourable field conditions. Under such conditions the tests shall be repeated.

Note. – The removable parts are not to be subjected to these voltage tests whilst they are in the disconnected, test or removed position.

For these dielectric tests, current transformers, any direct overcurrent release or overcurrent indicator and the cable terminal boxes (placed, if necessary, in several configurations if in doubt about the most unfavourable situation) should be installed as in normal service.

b) Across the isolating distance

Each isolating distance of the main circuit shall be tested using the test voltages specified in Sub-clause 6.1.5. The isolating distance may be the distance between the two parts of the main circuit intended to be connected by a withdrawn or removed switching device.

If, in the disconnected position, an earthed metallic shutter is interposed between the disengaged contacts to ensure segregation, the gap between the earthed metallic shutter and the live parts shall withstand only the test voltages required to earth.

If, in the disconnected position, there is no earthed metallic shutter between the fixed part and the withdrawable part, the test voltages specified across the isolating distance shall be applied:

- between the fixed and moving contacts intended to engage, if conductive parts of the main circuit of the withdrawable part can inadvertently be touched;

- between the fixed contacts on one side and the fixed contacts on the other side, with the switching device of the withdrawable part in the closed position, if they cannot inadvertently be touched.

c) Complementary tests

If the requirements of Items *d)* and *e)* of Sub-clause 5.103.3 are applicable, evidence shall be given of the required ability to withstand a power-frequency test-voltage of 150% of the rated voltage for 1 min.

In the case of gaseous or liquid insulation, during the test the inner surface of the insulation enclosure facing parts of the main circuit is covered by an earthed metal foil or conducting cloth and the test voltage is applied between this foil and all parts of the main circuit connected together.

6.1.5 *Test voltages*

Refer to Sub-clause 4.2.1 of IEC Publication 694.

The test voltages to earth and between phases shall be selected from Table I, columns (2) or (4) and (6) of IEC Publication 694, or the table of Appendix CC of this Publication, columns (2) and (4). The test voltages across the isolating distance shall be selected from Table I, columns (3) or (5) and (7) of IEC Publication 694, or the table of Appendix CC, columns (3) and (5).

6.1.6 *Lightning and switching impulse voltage tests*

Refer to Sub-clause 6.1.6 of IEC Publication 694, with the addition of the following supplement:

Insulation-enclosed switchgear and controlgear shall be subjected to lightning impulse voltage tests only.

Voltage transformers, power transformers or fuses may be replaced by replicas reproducing the field configuration of the high-voltage connections.

Overvoltage protective devices shall be disconnected or removed. Current transformer secondaries shall be short-circuited and earthed. Current transformers with a low ratio may have their primaries short-circuited too.

During the tests, the earthed terminal of the impulse generator shall be connected to the earthing conductor of the switchgear except that during the tests across an isolating distance (Sub-clause 6.1.4, Item *b)*), the earthing conductor shall, if necessary, be insulated from earth in order that the voltage appearing between any of the live parts and metal parts intended to be connected to the earthing conductor will not exceed the voltage specified for voltage tests to earth and between phases (Sub-clause 6.1.4, Item *a)*).

The conventional test procedure may be applied subject to agreement between manufacturer and user in order to avoid possible damage to the solid insulation.

The conventional impulse withstand test shall be performed by applying three consecutive impulses for each polarity. If no disruptive discharge occurs, the switchgear shall be considered to have passed the test.

Note. – It may be necessary for certain types of insulating material to eliminate residual charges before starting the tests with the opposite polarity.

6.1.7 *Power-frequency voltage tests on the main circuit*

Refer to Sub-clause 6.1.7 of IEC Publication 694, with the addition of the following supplement:

The main circuits of insulation-enclosed switchgear and controlgear shall be subjected to power-frequency voltage tests in dry conditions only.

Voltage transformers, power transformers or fuses may be replaced by replicas reproducing the field configuration of the high-voltage connections. Overvoltage protecting devices may be disconnected or removed.

During the tests, one terminal of the test transformers shall be connected to earth and to the earthing conductor of the switchgear except that during the tests across an isolating distance (Sub-clause 6.1.4, Item *b)*), the mid-point or another intermediate point of the voltage source should be connected to earth and to the earthing conductor in order that the voltage appearing between any of the live parts and metal parts intended to be connected to the earthing conductor will not exceed the voltage specified for voltage tests to earth and between phases (Sub-clause 6.1.4, Item *a)*).

If this is not practicable, one terminal of the test transformer may, with the agreement of the manufacturer, be connected to earth and the earthing conductor shall, if necessary, be insulated from earth.

6.1.8 *Artificial pollution tests*

IEC Publication 694 is not applicable.

6.1.9 *Partial discharge tests*

The measurement of partial discharges is a suitable means of detecting certain defects in the equipment under test and is a useful complement to the dielectric tests. Experience shows that partial discharges may lead in particular arrangements to a degradation in the dielectric strength of the equipment, especially of solid insulation. On the other hand, it is not possible to establish a reliable relationship between the results of partial discharge measurements and the life expectancy of the equipment owing to the complexity of the insulation systems used in insulation-enclosed switchgear and controlgear.

6.1.9.101 *Application*

The measurement of partial discharges is recommended for insulation-enclosed switchgear and controlgear as organic insulating materials are largely used therein, and should be made to show, in correlation with the other dielectric tests, if and where there are weak points with respect to the dielectric stresses resulting from the design of the equipment.

Because of the design variations a general specification for the test object cannot be given. In general, the test object should consist of assemblies or sub-assemblies with dielectric stresses identical to those which would occur in the complete assembly of the equipment.

Notes 1. – Test objects consisting of a complete assembly are to be preferred. In the case of integrated switchgear design, especially where various live parts and connections are embedded in solid insulation, tests on a complete assembly are necessary.

2. – In the case of designs consisting of a combination of conventional components (for instance instrument transformers, bushings) which can be tested separately in accordance with their relevant IEC standards, the purpose of this partial discharge test is to check the arrangement of the components in the assembly.

If partial discharge tests are made, they shall be carried out before and after the lightning impulse and power frequency voltage tests, and, for technical and economic reasons, on the same assemblies or sub-assemblies as used for these dielectric tests.

Note. – This measurement may be carried out on assemblies or sub-assemblies provided that discharges are eliminated which do not concern the solid insulation under test.

6.1.9.102 *Test circuits and measuring instruments*

The test circuits and measuring instruments recommended and methods of calibration are given in IEC Publication 270: Partial Discharge Measurements.

Three-phase equipment is tested either in a single-phase or in a three-phase test circuit (see Table II).

a) Single-phase test circuit

Procedure A

To be used as a general method for equipment designed for use in systems with or without solidly earthed neutral.

For measuring the partial discharge quantities, each phase shall be connected successively to the test voltage source, the other two phases and all the parts earthed in service being earthed.

Procedure B

To be used only for equipment exclusively designed for use in systems with solidly earthed neutral.

For measuring the partial discharge quantities, two test arrangements shall be used.

At first, measurements shall be made at a test voltage of 1.1 U (U is the rated voltage). Each phase shall be connected successively to the test voltage source, the other two phases being earthed. It is necessary to insulate or to remove all the metal parts normally earthed in service.

An additional measurement shall be made at a reduced test voltage of 1.1 $U/\sqrt{3}$ during which the parts being earthed in service are earthed and the three phases connected to the test voltage source are bridged.

b) Three-phase test circuit

When suitable test facilities are available, the partial discharge tests may be carried out in a three-phase test circuit.

In this case, it is recommended to use three coupling capacitors connected as shown in Figure 1, page 32. One discharge detector can be used, which is connected successively to the three measuring impedances.

For calibration of the detector in one measuring position of the three-phase arrangement, short-duration current pulses of known charge are injected between each phase in turn and earth. The calibration giving the lowest deflection is used for the determination of the discharge quantity.

6.1.9.103 *Test procedure*

The power-frequency test voltage is raised to at least 1.3 U or 1.3 $U/\sqrt{3}$ in accordance with the test circuit and maintained at this value for at least 10 s*.

The voltage is then decreased without interruption to 1.1 U or 1.1 $U/\sqrt{3}$ in accordance with the test circuit and the partial discharge quantities are measured at these test voltages.

Note. – If possible, taking into account the actual background noise level, the partial discharge inception and the partial discharge extinction voltages should be recorded as additional information.

In general, tests on assemblies or sub-assemblies should be made with the switching devices in the closed position. In the case of disconnectors where deterioration of the insulation between the open contacts by partial discharges is conceivable, additional partial discharge measurements should be made with the disconnector in the open position.

6.1.9.104 *Maximum permissible partial discharge intensity*

The maximum permissible partial discharge intensity at 1.1 U and/or 1.1 $U/\sqrt{3}$ shall be agreed between manufacturer and user.

Note. – Limit values of the partial discharge intensity cannot be specified until further substantiated information is available. For the time being, these values are the responsibility of the manufacturer or, in the case of acceptance tests, are subject to agreement between manufacturer and user.

For information only, the maximum permissible partial discharge intensities measured at 1.1 $U/\sqrt{3}$ and seeming acceptable on the basis of practical experience are given below for:

- bushings with cast resin insulation: 20×10^{-12} C;
- bushings with resin-bonded paper: 100×10^{-12} C;
- instrument transformers with solid insulation: 50×10^{-12} C;
- instrument transformers with liquid-impregnated insulation: 10×10^{-12} C.

Note. – These intensities do not necessarily apply to other components or to assemblies or sub-assemblies of the switchgear.
As a general rule, the intensity permitted for an assembly or sub-assembly should be the highest value permitted for its components.

6.1.10 *Dielectric tests on auxiliary and control circuits*

Refer to Sub-clause 6.1.10 of IEC Publication 694 which is applicable to all low voltage auxiliary circuits.

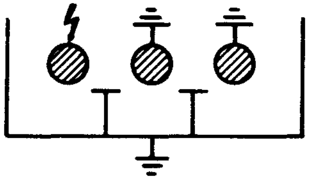
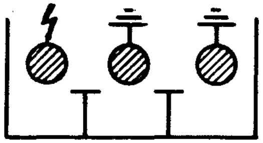
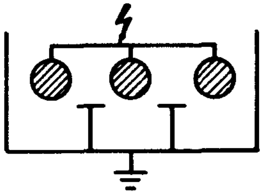
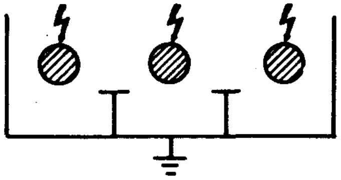
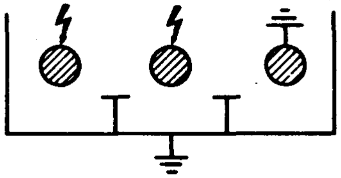
Current transformer secondaries shall be short-circuited and disconnected from earth. Voltage transformer secondaries shall be disconnected.

---

* Alternatively, the partial discharge test may be performed while decreasing the voltage after the power-frequency voltage tests.

TABLE II

Partial discharge test circuits and procedures

	Single-phase testing			Three-phase testing
	Procedure A	Procedure B		
Voltage source connected to	Each phase successively	Each phase successively	Three phases simultaneously	Three phases (Figure 1)
Earth-connected elements	Both the other phases and all the parts earthed in service	Both the other phases	All the parts earthed in service	All the parts earthed in service
Minimum prestress voltage	$1.3\,U$	$1.3\,U$	$1.3\,U/\sqrt{3}$	$1.3\,U$[1]
Test voltage	$1.1\,U$	$1.1\,U$	$1.1\,U/\sqrt{3}$	$1.1\,U$[1]
Basic diagram				 [2] 

---

[1] Voltage between phases.

[2] Additional test in case of a system without solidly earthed neutral (for type tests only).

6.2 *Radio interference voltage (RIV) tests*

IEC Publication 694 is not applicable.

6.3 *Temperature-rise tests*

Refer to Sub-clause 6.3 of IEC Publication 694 with the addition of the following supplement:

Where the design provides alternative components or arrangements, the test shall be performed with those components or arrangements for which the most severe conditions are obtained. The representative functional unit shall be mounted approximately as in normal service, including all normal enclosures of any part and with the covers and doors closed.

The tests shall be made normally with the rated number of phases and the rated normal current flowing from one end of the length of busbars to the terminals provided for the connection of cables.

When testing individual functional units, the neighbouring units should carry the currents which produce the power loss corresponding to the rated conditions. It is admissible to simulate equivalent conditions by means of heaters or heat insulation, if the test cannot be performed under actual conditions.

The temperature rises of the different components shall be referred to the ambient air temperature outside the enclosure and shall not exceed the values specified for them in the relevant standards.

6.4 *Measurement of the resistance of the main circuit*

Refer to Sub-clause 6.4 of IEC Publication 694.

6.5 *Short-time and peak withstand current tests*

Refer to Sub-clause 6.5 of IEC Publication 694 with the addition of the following supplement:

6.5.101 *Tests on main circuits*

Main circuits in insulation-enclosed switchgear and controlgear shall be tested to verify their capability to withstand the rated short-time and peak withstand current under the intended conditions of installation and use, i.e. they shall be tested as installed in the switchgear with all components influencing the performance or modifying the short-circuit current.

The short-circuit current tests should preferably be carried out three-phase. The r.m.s. value of the short-circuit current during the test shall be obtained by applying the rated short-time withstand current to the main circuit of the switchgear.

Short and direct connections between circuits having a high short-circuit current and current-limiting devices may be tested with a reduced short-circuit current.

With the exception of protective devices which limit the value and the duration of the short-circuit current, it is necessary to ensure that no protective device operates. Current transformers and tripping devices which may be present shall be installed as in normal service, but with the release made inoperative.

Current-limiting fuses, if any, shall be provided with fuse-links having the maximum rated current specified.

After the test no deformation or damage to components or conductors within the enclosure which may impair satisfactory operation of the main circuits shall have been sustained and the insulating properties of the insulation enclosure shall in particular be unimpaired. It may be possible to detect the presence of cracks in the insulation of insulation-embedded components by performing a partial discharge test (see Sub-clause 6.1.9).

6.5.102 *Tests on earthing circuits*

Earthing conductors, earthing connections and earthing devices of insulation-enclosed switchgear and controlgear shall be tested to verify their capability to withstand the rated short-time and peak withstand current under the neutral earthing condition of the system, i.e. they shall be tested as installed in the switchgear with all components influencing the performance or modifying the short-circuit current.

The short-circuit current tests with earthing devices should preferably be carried out in a three-phase test circuit.

When there are removable parts with earthed parts, their earthing connections shall be tested under earth fault conditions. The earth fault current shall flow between the earthing conductor and the earthed parts of the removable part. The earthing connection between two removable parts, if any, shall also be tested.

After the test some deformation and degradation of the earthing conductor, earthing connections or earthing devices is permissible, but the continuity of the circuit shall be preserved.

6.101 *Verification of making and breaking capacities*

Switching devices forming part of the main circuit of insulation-enclosed switchgear and controlgear shall be tested to verify their rated making and breaking capacities according to the relevant standards and under the proper conditions of installation and use, i.e. they shall be tested as normally installed in the switchgear with all components the arrangement of which may influence the performance, such as connections, supports, provisions for venting, etc.

Note. – In determining which associated components are likely to influence the performance, special attention should be given to mechanical forces due to the short circuit, the venting of arc products, the possibility of disruptive discharges, etc. It is recognized that, in some cases, such influences may be quite negligible.

6.102 *Mechanical operation tests*

6.102.1 *Switching devices and removable parts*

Switching devices shall be operated 50 times and removable parts inserted 25 times and withdrawn 25 times to verify satisfactory operation of the equipment.

6.102.2 *Interlocks*

The interlocks shall be set in the position intended to prevent the operation of the switching devices and the insertion or withdrawal of removable parts. Fifty attempts shall be made to operate the switching devices and 25 attempts shall be made to insert and 25 attempts to withdraw the removable parts. During these tests only normal operating force shall be employed and no adjustment shall be made to the switching devices, removable parts or interlocks.

The interlocks are considered satisfactory, if

a) the switching devices cannot be operated;

b) the insertion and withdrawal of the removable parts is prevented;

c) the switching devices, removable parts and the interlocks are in proper working order and the effort to operate them is practically the same before and after the tests.

6.103 *Verification of the degree of protection*

The tests shall be performed in accordance with the specifications in Clause 7 of IEC Publication 529 for the appropriate first characteristic numeral.

It shall be verified that the test instruments according to Table III cannot either:

- cause a lowering of the dielectric strength of the main circuit below the rated insulation level, or
- touch moving parts inside the enclosure,
- and in the case of IP2X, the specified rigid sphere does not pass through openings in the enclosure.

However, the test shall be made only if there are doubts on compliance with these requirements.

TABLE III

Degree of protection	Test instruments
IP2X	Standard metal test finger and rigid sphere of $12^{+0.05}_{0}$ mm diameter
IP3X	Straight rigid steel wire of $2.5^{+0.05}_{0}$ mm diameter
IP4X	Straight rigid steel wire of $1.0^{+0.05}_{0}$ mm diameter

6.104 *Measurement of leakage currents*

In order to check compliance with the requirement of item *c)* of Sub-clause 5.103.3, the main circuit of the insulation-enclosed switchgear and controlgear shall, at the discretion of the manufacturer, be connected either to a three-phase supply of power-frequency voltage equal to the rated voltage, with one phase connected to earth, or a single-phase supply of a voltage equal to the rated voltage, the live parts of the main circuit being connected together. For three-phase tests, three measurements shall be made with the different phases of the supply successively connected to earth. In the case of single-phase tests, only one measurement is necessary.

A metal foil shall be placed in the most unfavourable situation for the test on the accessible surface of the insulation enclosure. In case of doubt about the most unfavourable situation, the test shall be repeated with the foil in different positions.

The metal foil shall be approximately circular or square, having an area as large as possible but not exceeding 100 cm^2 and shall be connected to the earthing conductor. The leakage current flowing through the metal foil to earth shall be measured with the insulation dry and clean.

In order to check compliance with the requirement of leakage currents across the isolating distance of disconnectors (Sub-clause 5.105), the single-phase or three-phase test voltage shall be applied to one side of the open disconnector, the other side being earthed through a measuring instrument.

If the value of the leakage current measured is more than 0.5 mA, the insulation enclosure does not provide the protection required by this standard.

The measuring of leakage currents is not necessary if one of the following requirements is met:

a) if it is ensured by earthed metal parts arranged in an appropriate manner that leakage currents cannot reach the accessible parts of the enclosure;

b) if a gas gap of a dielectric strength sufficient to withstand 150% of the rated voltage is arranged between parts of the main circuit and the inner surface of the enclosure facing them.

Note. – The second requirement can by its nature only apply to parts of the enclosure: it is essential that the remainder of the enclosure meets the first requirement if the measurement of leakage currents is to be dispensed with.

The leakage current shall be measured also in conditions representing condensation and light pollution on the accessible surfaces of the insulation enclosure after the humidity test according to Sub-clause 6.108, if such a test was agreed.

6.105 *Mechanical strength test*

The mechanical strength of insulation enclosures shall be verified by an impact test during which blows are applied to the points of the enclosure that are likely to be the weakest. Three blows shall be applied to every point being checked. Unless otherwise agreed between manufacturer and user, impacts of 1 Nm should be applied.

The hammer head with which the impacts are applied has a hemispherical face, with a radius of 10 mm, of polyamide having a Rockwell hardness of R 100. The use of a spring-operated impact-test apparatus, as shown in Figure 2, page 33, is recommended.

After the test the enclosure shall show no cracks. Superficial damage can be ignored.

6.106 *Test under conditions of arcing due to internal fault*

This test is subject to agreement between manufacturer and user. If such a test is agreed, the procedure shall be in accordance with that described in Appendix AA.

Note. – The test procedure represents the effects of an internal arc occurring entirely in atmospheric air within the insulation enclosure when doors and covers are closed, but does not cover all cases, particularly those faults occurring within components and/or insulating media other than atmospheric air.

6.107 *Thermal stability test*

Where the major part of the insulation between conductive parts consists of solid insulation, the manufacturer shall provide evidence that the stability of the insulating materials used will not be impaired by dielectric stresses and thermal influences.

This evidence can be given on the basis of tests on comparable configurations, on the basis of the properties of the insulating materials (dielectric losses as a function of temperature) or by carrying out a thermal stability test on the whole equipment or a representative part of it.

This test is not necessary if gas or liquids form the major part of the insulation.

The thermal stability test consists of a 100 h test with a power-frequency voltage of 180% of the rated voltage at the temperature reached during a temperature-rise test according to Sub-clause 6.3 at an ambient air temperature of 40 °C.

The main circuit shall be energized by an earthed supply, using a three-phase supply with an earthed-neutral for three-phase switchgear. The earthing conductor and any metal parts intended to be earthed shall be connected to earth.

Note. – The test may be carried out separately from the temperature-rise test at the highest temperature rise measured during the temperature-rise test increased by 40 °C.

If no disruptive discharge occurs, the insulation-enclosed switchgear and controlgear shall be considered to have passed the test.

6.108 *Humidity test*

The humidity test should be made only at the special request of the user. The test procedure is given in Appendix BB.

6.109 *Ageing tests*

Test methods are under consideration.

7. **Routine tests**

The routine test shall be carried out on each transport unit and, whenever practicable, at the manufacturer's works to ensure that the product is in accordance with the equipment on which the type test has been carried out.

Refer to Clause 7 of IEC Publication 694 with the addition of the following routine tests:

	Sub-clause
– mechanical operation tests:	7.101
– tests of auxiliary electrical, pneumatic and hydraulic devices:	7.102
– verification of the correct wiring:	7.103
– partial discharge measurement:	7.104

Note. – It may be necessary to verify the interchangeability of components of the same rating and construction (see Clause 5).

7.1 *Power-frequency voltage tests on the main circuit*

Refer to Sub-clause 7.1 of IEC Publication 694 with the addition of the following supplement:

There are two alternative procedures:

a) If the insulation-enclosed switchgear and controlgear is an assembly of components which have not been tested individually, all the tests according to Sub-clause 6.1.4 shall be carried out except for lightning impulse voltage tests.

b) If the insulation-enclosed switchgear and controlgear is an assembly of components which individually have been subjected to appropriate routine tests, the tests according to this sub-clause serve in principle to prove the interconnections and the insulation enclosure.

The power-frequency voltage test shall be performed according to the requirements in Sub-clause 6.1.7. The test voltage specified in Table I, column (6), of IEC Publication 694 or in the table of Appendix CC, column (4), shall be applied connecting each phase conductor of the main circuit in turn to the high-voltage terminal of the test supply, with the other phase conductors connected to earth, and the continuity of the main circuit ensured (e.g. by closing the switching devices or otherwise).

In order to check compliance with the requirement of item *a)* of Sub-clause 5.103.3 the insulation enclosure shall be covered, on the accessible side in the most unfavourable situation for the test, with a metal foil not exceeding 100 cm^2 connected to earth.

Note. – On special request by the user and in addition to these routine tests at the manufacturer's premises, dielectric tests with a reduced test voltage may be performed after erection on site (see Appendix DD).

7.2 *Dielectric tests on auxiliary and control circuits*

Refer to Sub-clause 7.2 of IEC Publication 694.

7.3 *Measurement of the resistance of the main circuit*

IEC Publication 694 is not applicable. Subject to agreement between manufacturer and user, the d.c. voltage drop or resistance of each phase of the main circuit shall be measured under conditions as nearly as possible similar to those under which the corresponding type test was carried out.

7.101 *Mechanical operation tests*

Operation tests are carried out to ensure that the switching devices and removable parts comply with the prescribed operating conditions and that the mechanical interlocks work properly.

During these tests, which are performed without voltage on or current in the main circuits, it shall be verified, in particular, that the switching devices open and close correctly within the specified limits of the supply voltage and pressure of their operating devices.

Each switching device and each removable part shall be tested as specified in Sub-clause 6.102, but substituting five operations or five attempts in each direction.

7.102 *Tests of auxiliary electrical, pneumatic and hydraulic devices*

The electrical, pneumatic and other interlocks together with control devices having a predetermined sequence of operation shall be tested five times in succession under the intended conditions of use and operation and with the most unfavourable limit values of auxiliary supply. During the test no adjustment shall be made.

The tests are considered to be satisfactory if the auxiliary devices have operated properly, if they are in good operating condition after the tests and if the effort to operate them is practically the same before and after the tests.

7.103 *Verification of the correct wiring*

It shall be verified that the wiring conforms with the diagram.

7.104 *Partial discharge measurement*

The measurement of partial discharges is recommended to detect possible material and manufacturing defects. It may also be used as an acceptance test but only if agreed between manufacturer and user.

The partial discharge test may also be carried out on components.

Criteria to be considered in deciding on the necessity for a partial discharge test are, for instance:

a) Practical experience in service, including the results of such testing over a period of production.

b) The value of the electric field strength at the most highly stressed area of the solid insulation.

c) The type of insulating material used in the equipment as part of the major insulation.

8. **Guide to the selection of switchgear and controlgear for service**

Insulation-enclosed switchgear and controlgear is selected by considering the individual rated values of the components, which are required to comply with normal load and fault conditions for the particular service duty.

The rated values should be chosen in accordance with the suggestions contained in this standard and with due regard to the characteristics of the system including expected future development. The complete list of rating is given in Clause 4.

Other parameters such as local atmospheric and climatic conditions and the use at altitudes exceeding 1 000 m are also to be considered.

The duty imposed by fault conditions should be determined by calculating the fault currents at the place where the insulation-enclosed switchgear and controlgear is to be located in the system.

9. Information to be given with enquiries, tenders and orders

9.101 *Information to be given with enquiries and orders*

When enquiring for or ordering an installation of insulation-enclosed switchgear and controlgear the following information should be supplied by the enquirer:

1. Particulars of the system:
   Nominal and highest voltage, frequency, type of system neutral earthing.

2. Service conditions:
   Minimum and maximum ambient air temperature; any condition deviating from the normal service conditions or affecting the satisfactory operation of the equipment, as, for example, unusual exposure to vapour, moisture, fumes, explosive gases, excessive dust or salt; the risk of earth tremors or other vibrations due to causes external to the equipment to be delivered.

3. Particulars of the installation and its components:
   a) protection grade A or B to be provided by the insulation enclosure;
   b) number of phases;
   c) number of busbars;
   d) rated voltage;
   e) rated insulation level;
   f) rated normal currents of busbars and feeder circuits;
   g) rated short-time withstand current (I_{th});
   h) rated duration of short circuit (if different from 1 s);
   i) rated peak withstand current (if different from 2.5 I_{th});
   j) rated values of components;
   k) degree of protection for the insulation enclosure;
   l) circuit diagrams.

4. Particulars of the operating devices:
   a) type of operating devices;
   b) rated supply voltage (if any);
   c) rated supply frequency (if any);
   d) rated supply pressure (if any);
   e) special interlocking requirements.

In addition to these items the enquirer should indicate every condition which might influence the tender or the order, as, for example, special mounting or erection conditions, the location of the external high-voltage connections, etc.

It should be stated whether special type tests are required.

9.102 *Information to be given with tenders*

The following information, if applicable, should be given by the manufacturer with descriptions and drawings:

1. Rated values and characteristics as enumerated in item 3. of Sub-clause 9.101.
2. Type test certificates or reports on request.
3. Constructional features, for example:
   - a) mass of the heaviest transport unit;
   - *b)* overall dimensions of the installation;
   - *c)* arrangement of the external connections;
   - *d)* facilities for transport and mounting;
   - *e)* mounting provisions;
   - *f)* instructions for operation and maintenance.
4. Particulars of the operating devices:
   - a) types and rated values as enumerated in item 4. of Sub-clause 9.101;
   - *b)* current or power for operation;
   - *c)* operating times;
   - *d)* quantity of free gas for operation.
5. List of recommended spare parts which should be procured by the user.

10. **Rules for transport, storage, erection and maintenance**

Refer to Clause 10 of IEC Publication 694.

10.1 *Conditions during transport, storage and erection*

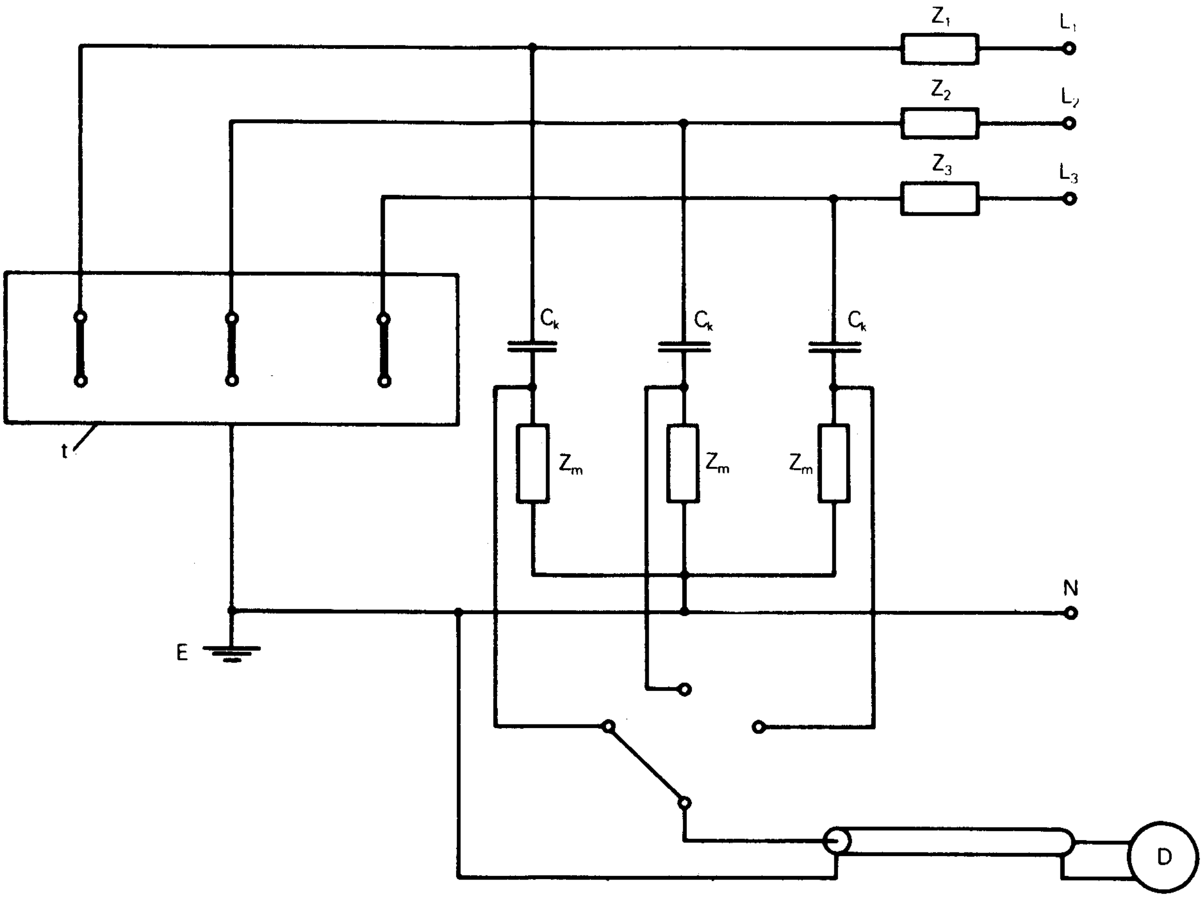
Refer to Sub-clause 10.1 of IEC Publication 694.

10.2 *Erection*

Refer to Sub-clause 10.2 of IEC Publication 694.

10.3 *Maintenance*

Refer to Sub-clause 10.3 of IEC Publication 694.



N = neutral connection

E = earth connection

L_1, L_2, L_3 = terminals for the connection of the three-phase voltage source

Z_1, Z_2, Z_3 = impedances of the test circuit

C_K = coupling capacitor

Z_m = measuring impedance

D = partial discharge detector

t = test object

FIG. 1. — Partial discharge test circuit (three-phase arrangement).

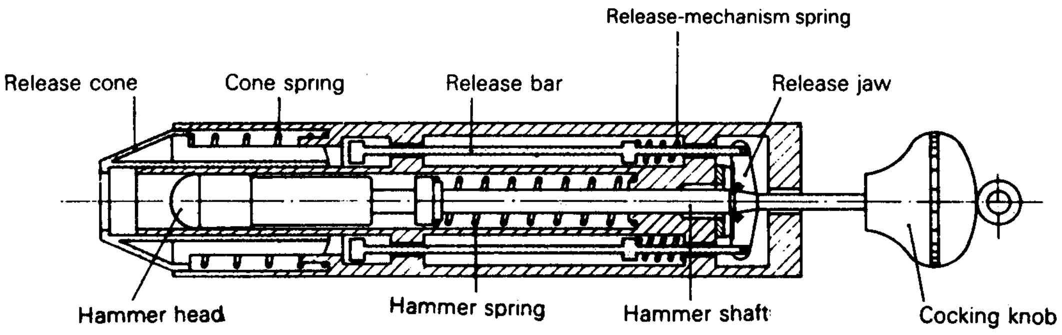


FIG. 2. — **Impact-test apparatus.**

APPENDIX AA

INTERNAL FAULT

TABLE AAI

Locations, causes and examples of measures decreasing the probability of internal faults or reducing the risk

Locations where internal faults are more likely to occur (1)	Possible causes of internal faults (2)	Examples of measures (3)
Cable boxes	Inadequate design	Selection of adequate dimensions.
	Faulty installation	Avoidance of crossed cable connections. Checking of workmanship on site.
	Failure of solid or liquid insulation (defective or missing)	Checking of workmanship and/or dielectric test on site. Regular checking of liquid levels.
Disconnectors Switches Earthing switches	Mal-operation	Interlocks (see Sub-clause 5.106). Delayed reopening. Independent manual operation. Short-circuit making capacity for switches and earthing switches. Instructions to personnel.
Bolted connections and contacts	Corrosion	Use of corrosion inhibiting coatings and/or greases. Encapsulation, where possible.
	Faulty assembly	Checking of workmanship by suitable means.
Instrument transformers	Ferroresonance	Avoidance of these electrical influences by suitable design of the circuit.
Circuit-breakers	Insufficient maintenance	Regular programmed maintenance. Instructions to personnel.
All locations	Error by personnel	Insulation-embedded live parts. Instructions to personnel.
	Ageing under electric stresses	Partial discharge routine tests.
	Pollution, moisture, ingress of dust, vermin, etc.	Measures to ensure that the specified service conditions are met (see Clause 2).
	Overvoltages	Lightning protection. Adequate insulation co-ordination. Dielectric tests on site.

TABLE AAII

Examples of measures limiting the consequences of internal faults

- Rapid fault clearance times initiated by detectors sensitive to light, pressure or heat or by a differential busbar protection
- Application of suitable fuses in combination with switching devices to limit the fault current and fault duration
- Remote control
- Pressure relief flaps

METHOD FOR TESTING THE ENCLOSED SWITCHGEAR AND CONTROLGEAR UNDER CONDITIONS OF ARCING DUE TO INTERNAL FAULT

AA1. **Introduction**

The occurrence of arcs inside enclosed switchgear and controlgear is coupled with various physical phenomena.

For example, the arc energy resulting from an arc developed in air at atmospheric pressure will cause an internal overpressure and local overheating, which will result in mechanical and thermal stressing of the equipment. Moreover, the materials involved may produce hot decomposition products, either gaseous or vaporous, which may be discharged to the outside of the enclosure.

This standard makes allowance for internal overpressure acting on covers, doors, inspection windows, etc., and also takes into consideration the thermal effects of the arc or its roots on the enclosure and of ejected hot gases and glowing particles, but not damage to partitions and shutters. Consequently, it does not cover all effects which may constitute a risk, such as toxic gases. Moreover, the test procedure only simulates situations when doors and covers are closed and correctly secured.

AA2. **Types of accessibility**

A distinction is made between the two types of accessibility corresponding to the different test conditions given in Sub-clauses AA5.3.2 and AA5.3.3. The enclosure may have different types of accessibility on its various sides.

Type A: Enclosed switchgear and controlgear with accessibility restricted to authorized personnel only.

Type B: Enclosed switchgear and controlgear with unrestricted accessibility, including by the general public.

AA3. **Test arrangement**

The choice of the functional units, their number, their equipment and their position in the room, as well as the place of initiation of the arc are to be decided upon in consultation. In each case, the following points shall be observed:

- the test should be carried out on a functional unit not previously subjected to arcing;
- the erection conditions should be as close as possible to those of normal service. The room should be represented at least by the floor, the ceiling, two perpendicular walls and the cable ducts;

- the functional unit should be fully equipped. Mock-ups of internal components are permitted provided they have the same volume and external material as the original items;
- the test unit shall be earthed at the point provided;
- the arc shall not be initiated in such a way that it can be considered unrealistic in service conditions.

AA4. Current and voltage applied

AA4.1 *General*

The tests on enclosed switchgear and controlgear should be carried out in a three-phase circuit. The short-circuit current applied during the test is to be stated by the manufacturer. It may be equal to or lower than the rated short-time withstand current.

AA4.2 *Voltage*

The applied voltage of the test circuit should be equal to the rated voltage of the enclosed switchgear and controlgear. A lower voltage may be chosen if the following conditions are met:

a) the current remains practically sinusoidal;

b) the arc is not extinguished prematurely.

AA4.3 *Current*

AA4.3.1 *A.C. component*

The short-circuit current, for which the enclosed switchgear and controlgear is specified with respect to arcing should be set within a +5% and 0% tolerance. These tolerances apply to the prospective current only if the applied voltage is equal to the rated voltage. The current should remain constant.

Note. — If the test plant does not permit this, the test should be extended until the integral of the a.c. component of the current equals the value specified within a tolerance of +10% and 0%. In this case, the current should be equal to the specified value at least during the first three half-cycles and should be not less than 50% of the specified value at the end of the test.

AA4.3.2 *D.C. component*

The instant of closing should be chosen so that the prospective value of the peak current (with a tolerance of +5% and 0%) flowing in one of the outer phases is 2.5 times the r.m.s. value of the a.c. component, defined in Sub-clause AA4.3.1, and so that a major loop also occurs in the other outer phase. If the voltage is lower than the rated voltage, the peak value of the short-circuit current for the enclosed switchgear and controlgear under test should not drop below 90% of the prospective peak value.

AA4.4 *Frequency*

At a rated frequency of 50 Hz or 60 Hz, the frequency at the beginning of the test should be between 48 Hz and 62 Hz. At other frequencies it should not deviate from the rated value by more than ±10%.

AA4.5 *Duration of the test*

The arc duration is chosen in relation to the probable duration of the arc, determined by the protection facilities.

Note. — The arc duration should not exceed 1 s up to an initial symmetrical short-circuit current of 25 kA. Above 25 kA it should be consistent with the service conditions of the equipment.

For testing enclosed switchgear and controlgear provided with pressure relief flaps, merely for proving its resistance to pressure, an arc duration of 0.1 s is generally sufficient.

Note. — It is in general not possible to calculate the permissible arc duration for a current which differs from that used in the test. The maximum pressure during the test will generally not decrease with a shorter arcing time and there is no universal rule according to which the permissible arc duration may be increased with a lower test current.

AA5. **Test procedure**

AA5.1 *Supply circuit*

The neutral is only earthed in the case of enclosed switchgear and controlgear to be operated in a solidly earthed system.

Care shall be taken that the connections do not alter the test conditions.

Generally, inside the enclosure, the arc may be fed from two directions: the direction to be chosen is the one likely to result in the highest stress.

AA5.2 *Arc initiation*

The arc should be initiated between the phases by means of a metal wire of about 0.5 mm diameter or, in the case of segregated phase conductors, between one phase and earth.

In functional units where the live parts are covered by solid insulating material, the arc should be initiated between two adjacent phases at joints or gaps of the insulation-embedded parts. The infeed shall be from a three-phase supply circuit to allow the arc to become a three-phase fault.

Note. — The arc shall not be initiated by perforating the solid insulation.

The point of initiation shall be chosen so that the effects of the resultant arc produce the highest stresses in the functional unit. In case of doubt it may be necessary to make more than one test on each functional unit.

AA5.3 *Indicators (for observing the thermal effects of gases)*

AA5.3.1 *General*

Indicators are pieces of black cotton cloth so arranged that their cut edges do not point toward the test unit. Care shall be taken to see that they cannot ignite each other. This is achieved by fitting them, for example, in a mounting frame of steel sheet (see Figure AA1, page 40). The indicator dimensions should be about 150 mm × 150 mm.

AA5.3.2 *Accessibility Type A*

Indicators should be fitted vertically at the operator's side of the enclosed switchgear and controlgear and, if applicable, at sides which are readily accessible to personnel.

They should be placed, up to a height of 2 m and at a distance of 30 cm ±5% from the enclosed switchgear and controlgear, facing all points where gas is likely to be emitted (e.g. joints, inspection windows, doors). Indicators should also be arranged horizontally at a height of 2 m above the floor and between 30 cm and 80 cm from the enclosed switchgear and controlgear (see Figure AA2, page 41).

Black cretonne (cotton fabric approximately 150 g/m^2) should be used for the indicators.

AA5.3.3 *Accessibility Type B*

Indicators should be fitted vertically on all accessible sides of the enclosed switchgear and controlgear.

They should be placed, up to a height of 2 m and at a distance of 10 cm ±5% from the enclosed switchgear and controlgear, facing all points where gas is likely to be emitted (e.g. joints, inspection windows, doors). Indicators should also be arranged horizontally at a height of 2 m above the floor and between 10 cm and 80 cm from the enclosed switchgear and controlgear. If the test unit is lower than 2 m, indicators should be placed horizontally on the top covers, facing all points where gas is likely to be emitted and close to the vertical indicators, which in this case, are only required up to the actual height of the equipment (see Figure AA2).

Black cotton-lawn (approximately 40 g/m^2) should be used for the indicators.

AA6. **Assessment of the test**

The following criteria allow for the arcing effects listed in Clause AA1. Whoever requests the test to be performed shall decide by which of these criteria the results of the test should be assessed.

It is to be observed:

Criterion No. 1

Whether correctly secured doors, covers, etc., do not open.

Criterion No. 2

Whether parts (of the enclosed switchgear and controlgear), which may cause a hazard, do not fly off. This includes large parts or those with sharp edges, for example, inspection windows, pressure relief flaps, cover plates, etc., made of metal or plastic.

Criterion No. 3

Whether arcing does not cause holes to develop in the freely accessible external parts of the enclosure as a result of burning or other effects.

Criterion No. 4

Whether the indicators arranged vertically (Sub-clause AA5.3) do not ignite. Indicators ignited as a result of paint or stickers burning are excluded from this assessment.

Criterion No. 5

Whether the indicators arranged horizontally (Sub-clause AA5.3) do not ignite. Should they start to burn during the test, the assessment criterion may be regarded as having been met, if proof is established of the fact that the ignition was caused by glowing particles rather than hot gases. Pictures taken by high-speed cameras should be produced in evidence.

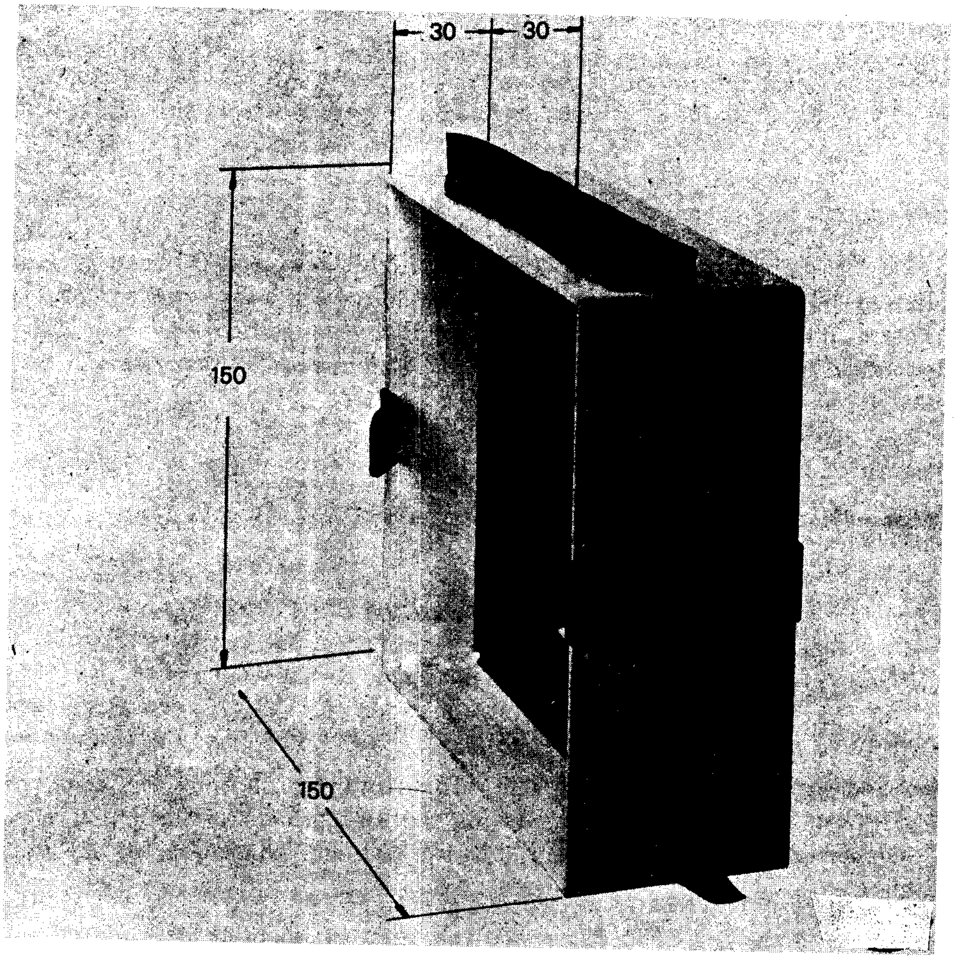
Criterion No. 6

Whether all the earthing connections are still effective.

AA7. **Test report**

The following information should be given in the test report:

- Rating and description of the test unit with a drawing showing the main dimensions, details relevant to the mechanical strength, the arrangement of the pressure relief flaps and the method of fixing the enclosed switchgear and controlgear to the floor and to the walls.
- Arrangement of the test connections and the point of initiation of the arc.
- Arrangement and material of indicators with respect to the type of accessibility.
- For the prospective or test current:
  a) r.m.s. value of the a.c. component during the first three half-cycles;
  b) highest peak value;
  c) average value of the a.c. component over the actual duration of the test;
  d) test duration.
- Oscillogram(s) showing currents and voltages.
- Assessment of the test results.
- Other relevant information.



Dimensions in millimetres

FIG. AA1. — Mounting frame for indicators.

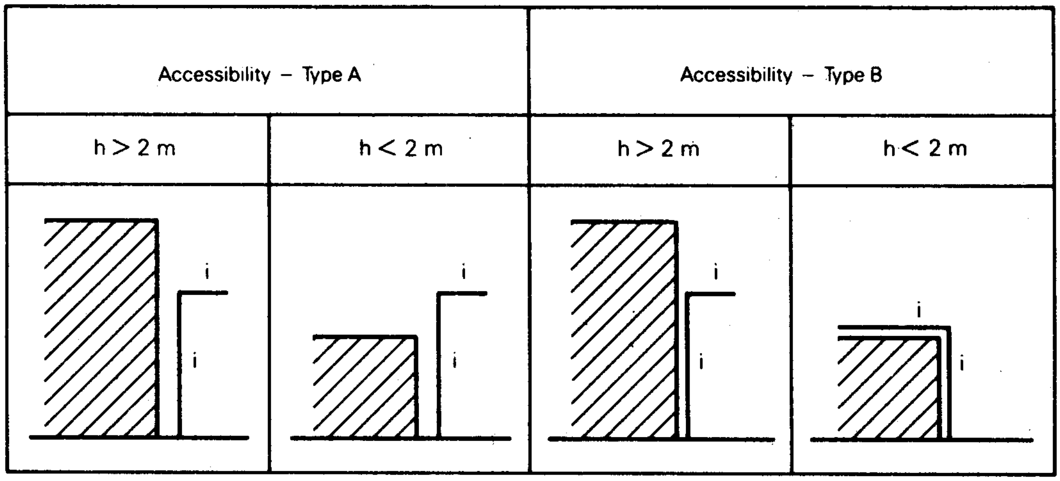


FIG. AA2. — Position of indicators (i)
Height of equipment (h)

APPENDIX BB

HUMIDITY TEST

BB1. General

The object of the humidity test is to prove that the insulation-enclosed switchgear and controlgear is safe when touched on the accessible surface of the insulation enclosure, not only in a dry state but also with condensation and light pollution.

Under normal service conditions the ambient air is not materially polluted. This statement does not exclude, however, the possibility of a certain degree of pollution occurring in the course of time, depending on the frequency and quality of cleaning and reconditioning of the insulation surfaces.

This humidity test does not cover the security requirements relating to other influencing factors, although the philosophy of this test may serve as a base for an ageing test in connection with reliability in general.

The insulation-enclosed switchgear and controlgear is exposed to a certain number of identical humidity and temperature cycles in a test chamber, in which the humidity is generated by fog formed from conductive water. During this test an a.c. power-frequency voltage is continuously applied to the test object.

BB2. Test procedure and test conditions

BB2.1 *Test cycle and its duration*

The test cycle should be chosen so that all the surfaces of the test object are wet during about half of its duration and dry during the other half. To obtain this result the test cycle consists of a period with low air temperature (T_{min}) and a period with high air temperature (T_{max}) inside the test chamber. Both periods shall be equal in time and the generation of fog shall be maintained for the first half of the test cycle. The temperature variation between the two periods shall be (10 ± 2) K. The value of the low air temperature (T_{min}) shall be approximately equal to the ambient air temperature outside the test chamber (see Figure BB1, page 45).

The beginning of fog generation (t_0) coincides in principle with the beginning of the low air temperature period. However, to wet the vertical surfaces of materials with a high thermal time-constant, it may be necessary to start the fog generation later within the low air temperature period.

The duration of the test cycle depends on the thermal characteristics of the insulation-enclosed switchgear and controlgear, and shall be sufficiently long both at high and low temperatures to cause wetting or drying of all the insulation surfaces.

Preliminary cycles shall be carried out with the test object placed in the test chamber in order to observe and to check these conditions.

The temperature and the relative humidity of the air in the test chamber shall be measured in the immediate vicinity of the insulation enclosure and shall be recorded for the whole duration of the test.

Note. — In order to achieve the required conditions a duration of the test cycle of 8 h is generally satisfactory.

BB2.2 *Generation of fog*

The fog is obtained by the continuous or periodical atomizing of 0.2 dm^3 to 0.5 dm^3 conductive water per hour and per cubic metre of test chamber volume. The resistivity of the water shall be 30 Ωm with a tolerance of ±10% (equivalent to a conductivity of 0.033 S/m) at the lower value of the test cycle temperature.

The diameter of the droplets shall be less than 10 µm. Such a fog may be achieved by mechanical atomizers situated at the bottom of the test chamber and directed upwards in such a manner that the insulation surfaces of the test object will not be sprayed directly. No water shall drop from the ceiling upon the test object.

During the fog generation the test chamber shall be closed and no additional forced air-circulation is permitted.

Notes 1. — For the adjustment of the conductivity of the water, sodium chloride (NaCl) is added to distilled water. If a suitable supply of tap water is available, it may be used also.

2. — The relation between conductivity of the water and its temperature is given in IEC Publication 60-1.

BB2.3 *High air temperature period*

The high air temperature is achieved with the aid of a heater in combination with forced air-circulation inside the test chamber. This forced circulation shall not be directed at the test object.

BB2.4 *Test chamber*

A proposal for an appropriate test chamber with thin walls is made in Figure BB2, page 45.

The volume of the test chamber shall be at least five times the circumscribed volume of the test object. The test chamber shall not be higher than 2.5 m and the base dimensions shall ensure that the test object placed on the bottom will have a minimum distance from the wall of 0.15 m and from the atomizer of 0.5 m.

Notes 1. — No special requirements are stated for the wall materials of the test chamber. However, materials having a high heat conductivity and a low thermal inertia are recommended because in this case the transition periods between wetting and drying and between drying and wetting will not significantly influence the time during which the insulation surfaces of the test object are wet.

2. — If the walls do not meet these conditions, special measures should be taken to ensure that the period during which the insulation surfaces are wet is approximately equal to half the duration of one test cycle.

BB2.5 *Test object*

The insulation-enclosed switchgear and controlgear to be tested shall be in new condition with its outside insulation surfaces clean. It shall be mounted in the test chamber in its usual upright position, complete with all insulating parts and the continuity of the main circuit ensured. Precautions shall be taken to ensure that no deposit of water accumulates inside the insulation enclosure during the test.

BB2.6 *Test voltage and voltage supply*

During the humidity test the following power-frequency voltages shall be continuously applied to the main circuit of the insulation-enclosed switchgear and controlgear:

- rated voltage U between phases;
- $U/\sqrt{3}$ between phase and earth.

BB2.7 *Total test duration*

The total duration during which the surfaces are wet shall be 120 h. Normally, the period of fog generation equals the period of wet surfaces which shall be approximately equal to half the duration of one test cycle; thus the total duration of the humidity test will be a minimum of 240 h.

If during the preliminary cycles a considerable difference is observed between the period of fog generation and the corresponding period during which the surfaces are wet, the test shall be based on the total duration during which the insulation surfaces are wet.

BB3. **Test criteria and evaluation**

BB3.1 *Criterion during the test*

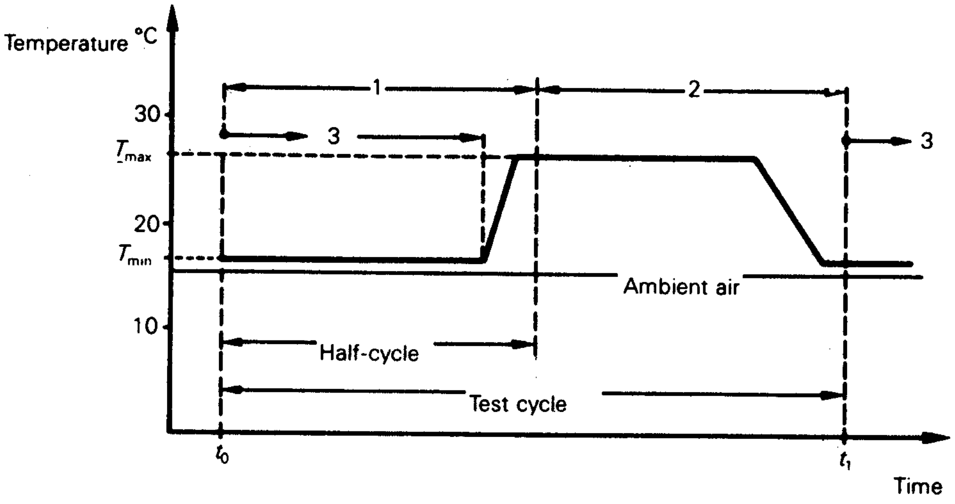
During the total duration of the humidity test no flash-over shall occur, neither between phases nor between phase and earth.

BB3.2 *Criterion after the test*

The humidity test shall be followed, without any cleaning, by a supplementary test cycle. During the wet surface period, the leakage current shall be measured in accordance with Sub-clause 6.104. The leakage current to earth through the metal foil at any accessible place and at any time of this period shall not exceed 0.5 mA. Further supplementary test cycles may be carried out in order to verify the value of the leakage current with the metal foil attached to different places of the accessible surfaces.

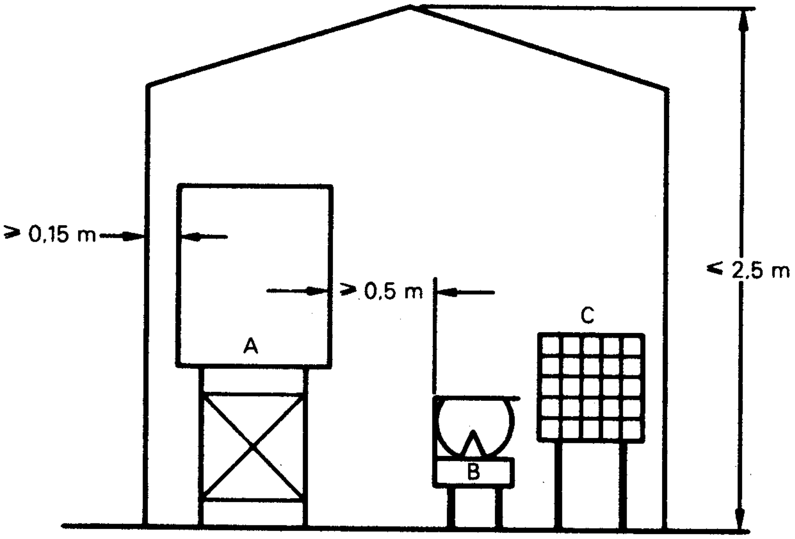
BB3.3 *Evaluation of the test*

If the criteria in Sub-clauses BB3.1 and BB3.2 are met, the insulation-enclosed switchgear and controlgear shall be considered to have passed the humidity test.



1 = wet surface period
2 = dry surface period
3 = fog generation

FIG. BB1. — Test cycle.



A = test object
B = atomizer
C = radiator

FIG. BB2. — Test chamber.

APPENDIX CC

RATED INSULATION LEVEL FOR SERIES II
(Based on current practice in Canada and the United States of America)

This appendix gives for information the rated insulation levels for Series II, based on current practice in Canada and the United States of America for 60 Hz only.

Rated voltage U (r.m.s. value) (kV)	Rated lightning impulse withstand voltage (peak value)		Rated power-frequency withstand voltage (r.m.s. value)	
	To earth and between phases (kV)	Across the isolating distance (kV)	To earth and between phases (kV)	Across the isolating distance (kV)
(1)	(2)	(3)	(4)	(5)
4.76	60	66	19	21
8.25	75	83	26	29
15	95	105	36	40
15.5	110	121	50	55
25.8	125	138	60	66
38	150	165	80	88

APPENDIX DD

GUIDE FOR DIELECTRIC TESTS AFTER ERECTION ON SITE

When agreed between manufacturer and user, power-frequency voltage tests in dry conditions may be carried out on the main circuits of the enclosed switchgear and controlgear after erection on site in exactly the same manner as specified in Sub-clause 7.1 for the routine test at the manufacturer's premises.

The power-frequency test voltage shall be 80% of the values indicated in Sub-clause 7.1 and shall be applied to each phase conductor of the main circuit in succession with the other phase conductors earthed. For the tests, one terminal of the test transformer shall be connected to earth and to the earthing conductor of the enclosed switchgear and controlgear.

If the voltage test after erection on site replaces the routine test at the manufacturer's premises, the full power-frequency test voltage shall be applied.

D.C. voltage tests are under consideration.

AMENDMENT NO. 1

Page 10

Replace the title, the text and table I of subclause 5.101.1 by the following:

5.101.1 *Protection of persons against access to hazardous parts and protection of the equipment against solid foreign objects*

Refer to IEC 694.

Page 11

Replace the titles and the texts of subclauses 5.101.2 and 5.101.3 by the following:

5.101.2 *Protection against ingress of water*

Refer to IEC 694.

5.101.3 *Protection of equipment against mechanical impacts under normal service conditions*

Refer to IEC 694. However, the impact energy is limited to 1 Nm.

Page 15

6 Type tests

Replace, on page 16, in the list of normal type tests, item f) by the following:

f) Tests to verify the protection of persons against access to hazardous parts and the protection of the equipment against solid foreign objects. Subclause 6.103

Replace, on page 16, in the list of special type tests, item h) by the following:

h) Tests to verify the protection of the equipment against mechanical impact:	Subclause 6.105

Page 25

Replace the title, the text and table III of subclause 6.103 by the following:

6.103 *Verification of the IP-coding*

Refer to IEC 694.

Page 26

Replace the title and the text of subclause 6.105 by the following:

6.105 *Mechanical impact test*

Refer to IEC 694.

Page 33

Delete figure 2.

(Continued from second cover)

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 298 : 1981 A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 72.5 kV	IS 3427 : 1997	Identical
IEC 529 : 1976 Degrees of protection provided by enclosures (IP Code)	IS 12063 : 1987	Equivalent
IEC 621-1 : 1978 Electrical installations for outdoor sites under heavy conditions, Part 1 : Scope and definitions	No ISS exists	do
IEC 694 : 1980 Common clauses for high-voltage switchgear and controlgear standards	IS 12729 : 1988	do

Only the English language text in the International Standard has been retained while adopting it in this Indian Standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc : No. ET 08 (5017).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 323 01 31, 323 94 02, 323 33 75
Telegrams: Manaksanstha
(Common to all offices)

Regional Offices:	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	323 76 17 323 38 41
Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola CALCUTTA 700054	337 84 99, 337 85 61 337 86 26, 337 86 62
Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160022	60 38 43 60 20 25
Southern : C. I. T. Campus, IV Cross Road, CHENNAI 600113	235 02 16, 235 04 42 235 15 19, 235 23 15
Western : Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400093	832 92 95, 832 78 58 832 78 91, 832 78 92

Branches : AHMADABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR. PATNA. PUNE. THIRUVANANTHAPURAM.

Printed at New India Printing Press, Khurja, India